Summary of Science Requirements: Biosphere

Irena Hajnsek & Tandem-L Science Team

Tandem-L Science Coordinator

Deutsches Zentrum
DLR für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

What do I have captured from the 4 day workshop?

- Very active science community
- High quality science content
- Straggling with models and data – and their uncertainties
- and what I will connect to this workshop: ‘come out of the scientific comfort zone‘

Simplified summary of science requirements for forest characterisation

- Mapping disturbance
- Capturing heterogeneity
- Monitoring events/ fast changes

Translation into a RS system requirement

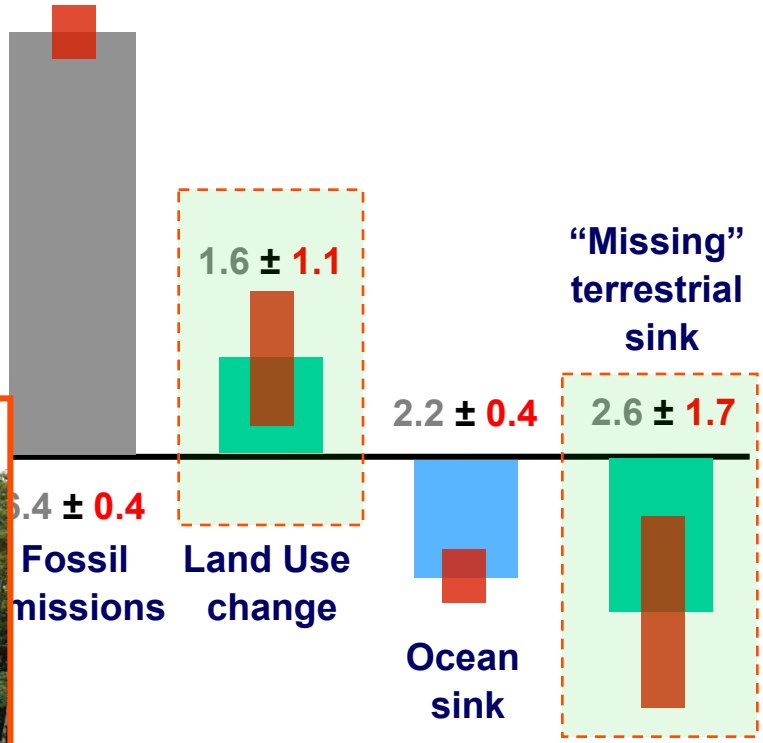
- High resolution system
- Frequent observation
- Long term monitoring

European and US scientist have similar needs

Biosphere

Carbon Cycle and (Forest-)Biomass

The terrestrial (vegetation-) component is the largest unknown in the quantification of the global Carbon Cycle;



Biosphere

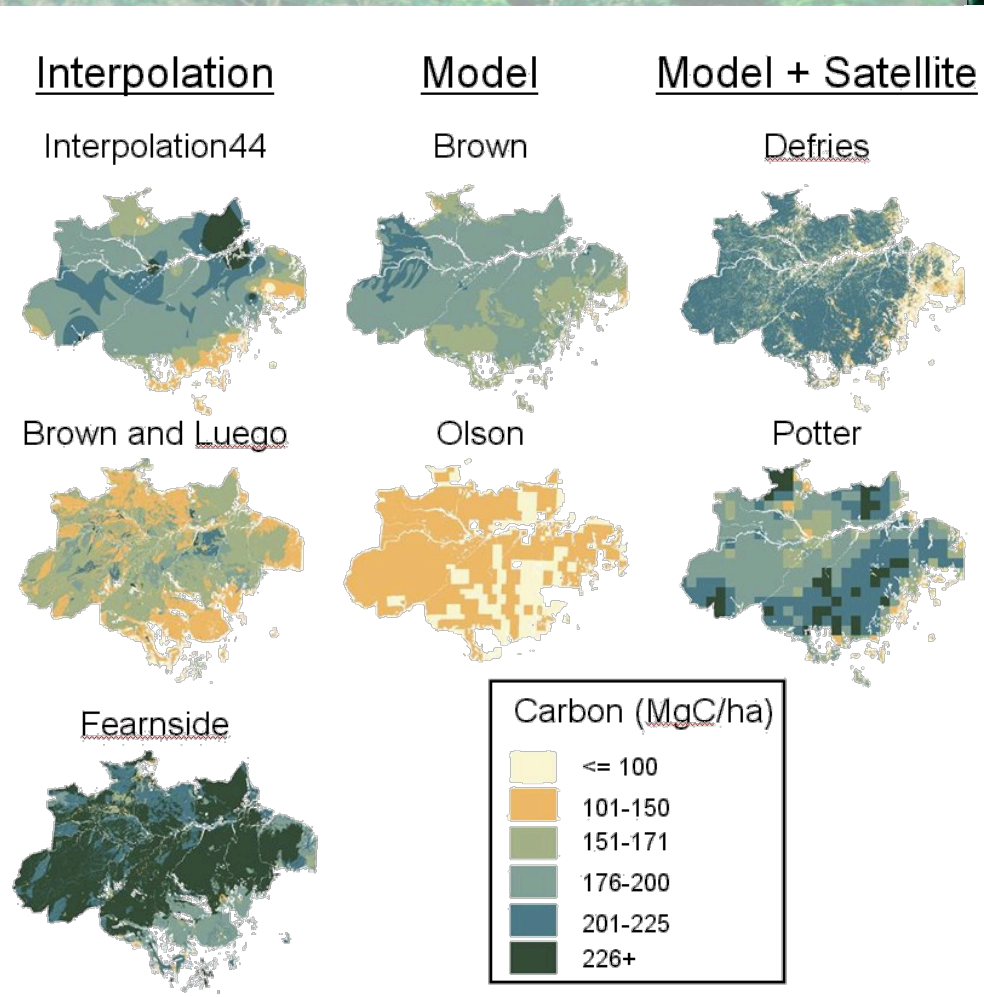
Carbon Cycle and (Forest-)Biomass

Biomass characterises the spatial distribution of Carbon (~50% of the biomass is C);

Biomass-Inventory & -Dynamics are today - in a global scale - unknown !

Amazonas basin

… the estimates vary between 39 to 93 GtC



Houghton et al. 2001

Biosphere

Carbon Cycle and (Forest-)Biomass

Changing climate conditions can convert vegetation:

In dry conditions forest has been reported to become a Carbon source!

- Europe 2003 with +0.5 Gt C (from -0.4Gt C)
- Amazon 2005 with +1.6 Gt C (from -1.3Gt C)

Cias et al. 2005 Nature, Phillipps et al. 2009 Science

In comparison: Total C emission in the Atmosphere is ~ 3 Gt C / Year

Biosphere

Biodiversity & Forest

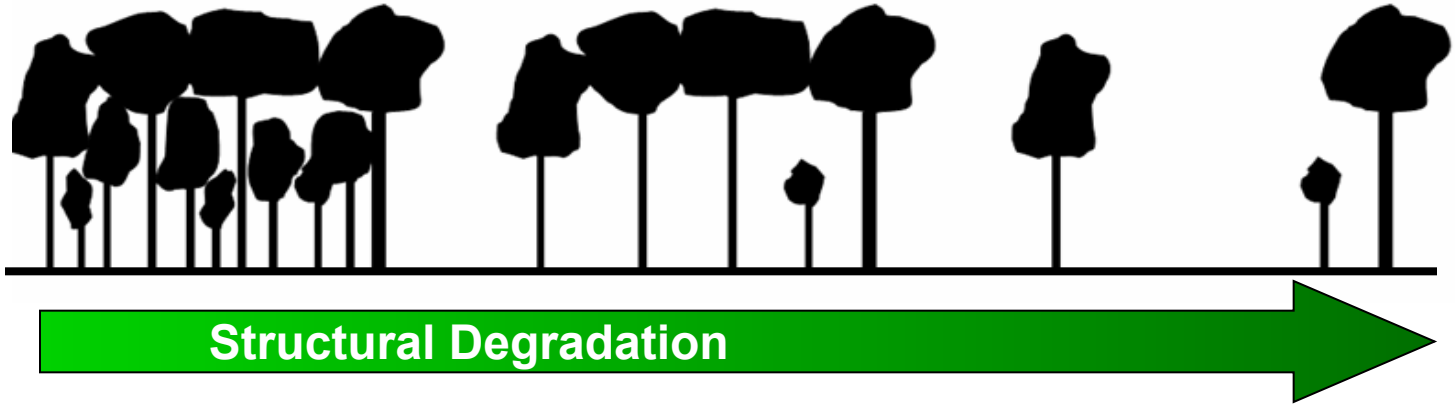
- 80% of the terrestrial Biodiversity lives in - primarily tropical – Forest-Ecosystems.

Biosphere

Biodiversity & Forest

- 80% of the terrestrial Biodiversity lives in - primarily tropical – Forest-Ecosystems.
- Besides the reduction of forested areas (deforestation), forest fragmentation and degradation impacts biodiversity seriously.

Structural degradation of forest (caused by legal / illegal logging, fire and other human activities) is not possible to be detected with conventional remote sensing techniques.



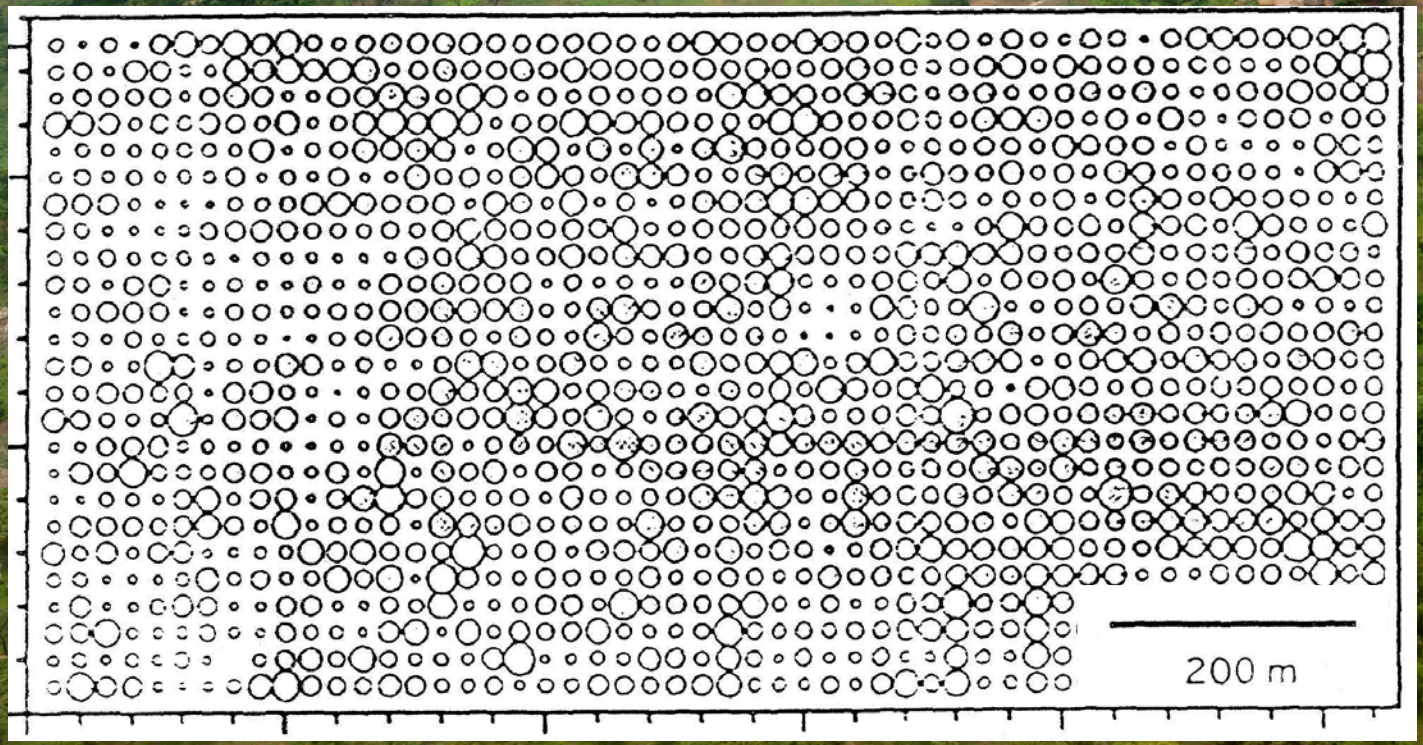
Institute for World Forestry

Biosphere

Challenge

High spatial variability of local biomass (due to natural disturbance regimes and human activities) and structure (vertical & horizontal):

Example: Lowland tropical forest in Lambir, Malaysia (Yoneda et al. 1996, 50ha, 200.000 trees)



Size of circles indicate local biomass (20x20 m, 1300 plots)

Summary BIOSPHERE (Forest)

Info Layer	Background	Users	Questions	Applications	Products
Level 1 (global)	Unknown forest biomass for understanding of global C-Cycle	Scientist, Ecologist, Climate Research	Quantification of biomass/C storage & change	Annual Inventory; Forest height & structure as key variable	Annual carbon, biomass & error quantification
Level 2 (regional)	Forest & environmental policy Certification Info on global level is only patchy	Government, Politicians, NGO's	State of forest resources & change; agreement with political goals; problematic spots (defor., diversity, endangered people); socio-economical traits	Status & change of biomass, carbon-stock, structure (vertical/horizontal); identify / quantify logging & large scale damage	Status & change maps of biomass, carbon stock, height , structure
Level 3 (local)	Sustainability Income for forest owners Provide production & protection functions	Managers of large private & public enterprises & forest unions	Info on regional/local state of forest resources & change; basis for operational management deicsion (high resolution)	High-resolution-status & change of biomass, structure (storm/snow risk, habitat); height (as a site quality indicator, risk); on demand info.; pre-selection of areas for inventories	Depending on IT structure of user; in general info. layers are needed for management, precision & high spatial resolution

Applications (Ecosystem / Management / Monitoring)						
Attributes/ Application	**Used Parameter**	**Avg. Uncertainties**	**Min. Mapping Unit [m]**	**Observation Frequency**	**Coverage**	**Description**
Carbon dynamic	**Biomass/ B. change**	**20-30%**	**100x100**	**yearly**	**global**	**Climate Research**
Forest Disturbance	**Height change / structure change**	**10-20 % / ± 1 layer**	**20x20-100x100**	**2 weekly to monthly**	**regional**	**Illegal logging, storm, insects (salvage logging), fire**
Stock estimation	**Biomass**	**10%-(20%)**	**50x50**	**1x 5 years**	**regional**	**F. Inventory**
Stand delineation	**Biomass / F. Height**	**10%**	**10x10-20x20**	**1x 5 years**	**local**	**F. management planning**
Site quality estimation	**F. Height**	**~2.5 – 5%**	**20x20-50x50**	**1 – 5 years**	**local**	**Combination with forest age**
Soil Moisture under Forest	**Soil Moisture**	**4 classes**	**50x50-100x100**	**On request**	**regional**	**Fire warning**
Forest Monitoring	**F. structure / change**	**± 1 layer**	**3 veg. layer**	**yearly**	**regional**	**Preservation of ecosystems**
Water dynamic	**Underline topography**	**~ 4m**	**20x20**	**5 years**	**regional**	**Water dynamic**
Flooding events	**F. Structure change / topo. Change**	**20-30%**	**50x50-100x100**	**monthly - seasonally**	**regional**	**Adapted to the local weather conditions**

Biosphere: Basic Observables

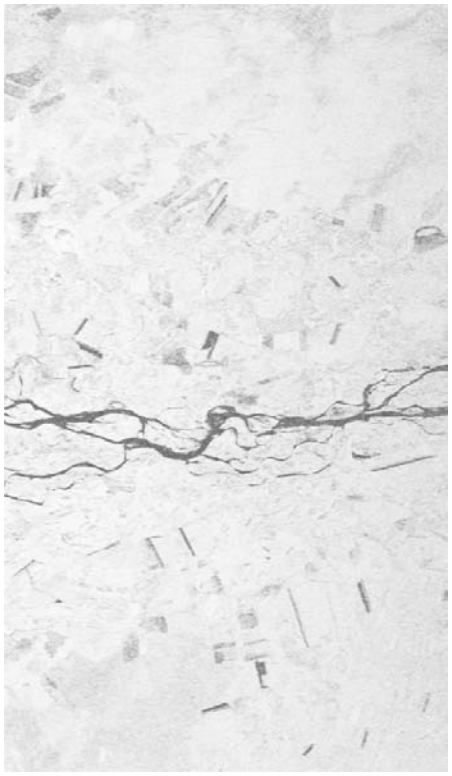
Attributes/ Parameters	Coverage	Avg. Uncertainties	Min. Mapping Unit [m]	Observation Frequency	Observation Interval	Description
Forest Height	global	~ 10% (-20%)	30x30-50x50	12 months	> 5 years	For biomass estimation
	regional	~ 10% (-20%)	20x20–30x30	3-5 years	> 5 years	For forest inventory
	local	(2.5) – 10%	<<10x10–20x20	2-5 years	> 5 years	Site quality estimates
Forest structure	global	3 v-layers 5-10m	30x30–50x50	seasonal	> 5 years	Contribution to biomass, Forest monitoring
	regional	3 v-layers 5-10m	20x20–30x30	on demand	> 5 years	Disturbance, Monitoring
Forest Biomass	global	≥20t/ha then 20 - 30%	70x70-100x100	12 months	> 5 years	Carbon stock
	regional	10 – 15t/ha ≤or 20%	≤ 50x50	5 years	> 5 years	For forest inventory
Underlying topography	global	< 4 m	30x30-50x50	12 months	> 5 years	Water dynamic

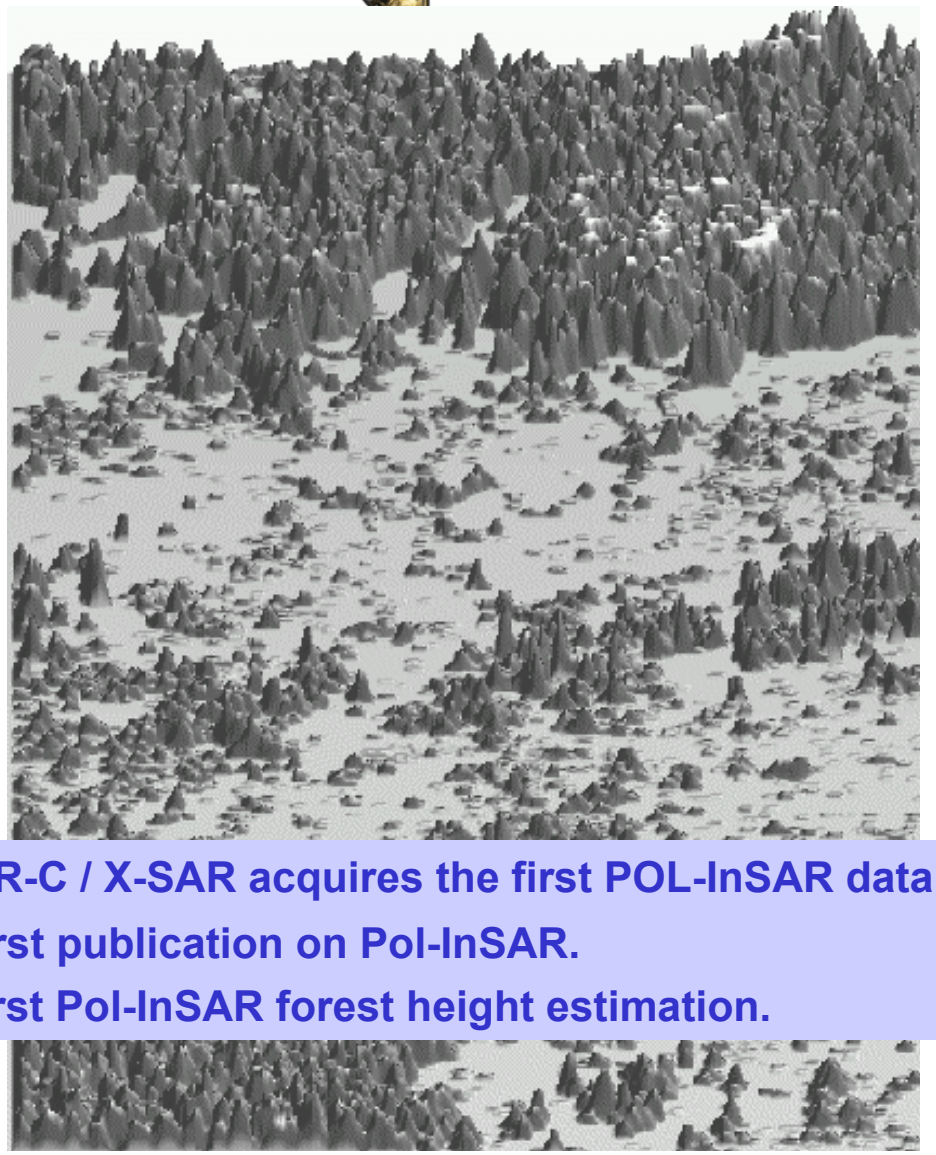
Biosphere: Change Detection

Attributes/ Parameters	Coverage	Avg. Uncertainties	Min. Mapping Unit [m]	Observation Frequency	Observation Interval	Description
Forest Height Change	global	From 1m to 20 - 30% (of change)	30x30-50x50	yearly	>5 years	For biomass change
	regional	From 1m to 20 - 30% (of change)	20x20–30x30	on demand	>5 years	For F. disturbance
Forest Structure Change	global	± 1 layer of change	30x30–50x50	yearly	>5 years	Contribution to biomass
	regional	± 1 layer of change	20x20–30x30	on demand	>5 years	Forest monitoring
Forest Biomass Change	global	From 5t/ha to 30% (of change)	70x70-100x100	yearly	>5 years	Carbon change
	regional	From 5t/ha 20 - 30% (of change)	≤ 50x50	5 years	>5 years	For F. inventory
Underlying topography change	regional	From 1m to 20 - 30% (of change)	30x30-50x50	on demand	>5 years	Flooding events

The beginning of Pol-InSAR…

SIR-C/X-SAR / Test Site: Kudara, Russia





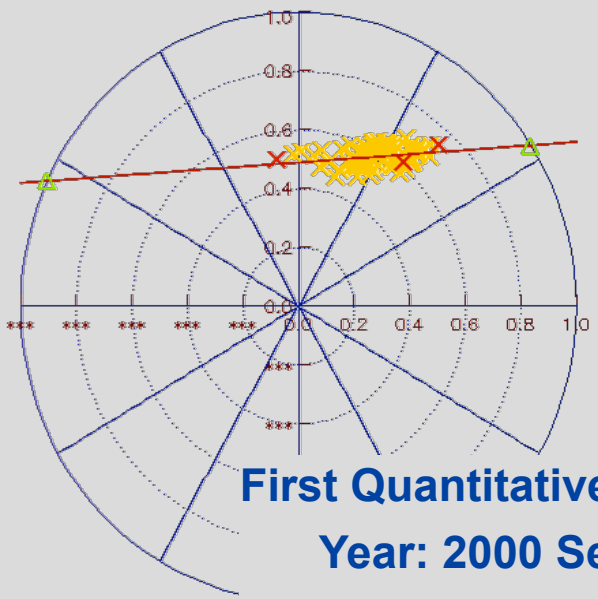
L-band / Pauli RGB

1994: SIR-C / X-SAR acquires the first POL-InSAR data

1996: First publication on Pol-InSAR.

1998: First Pol-InSAR forest height estimation.

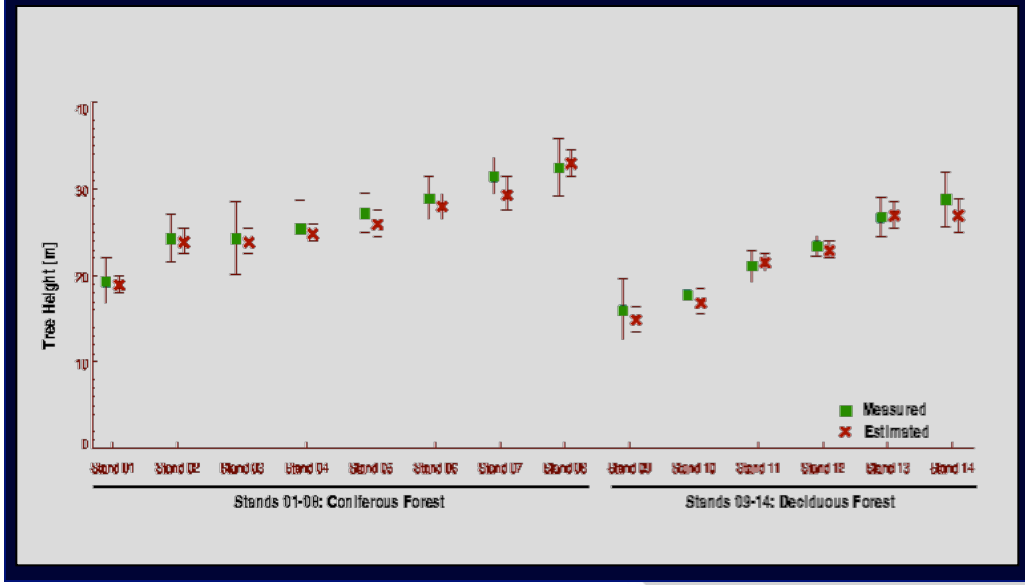
PoI-InSAR Forest Height Inversion (2000): DLR Site

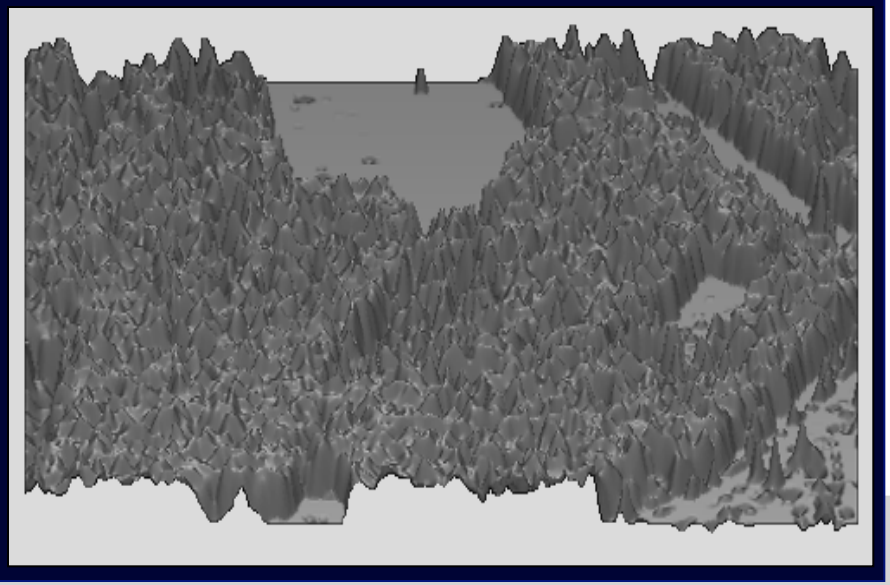


First Quantitative PoI-InSAR Demonstration:

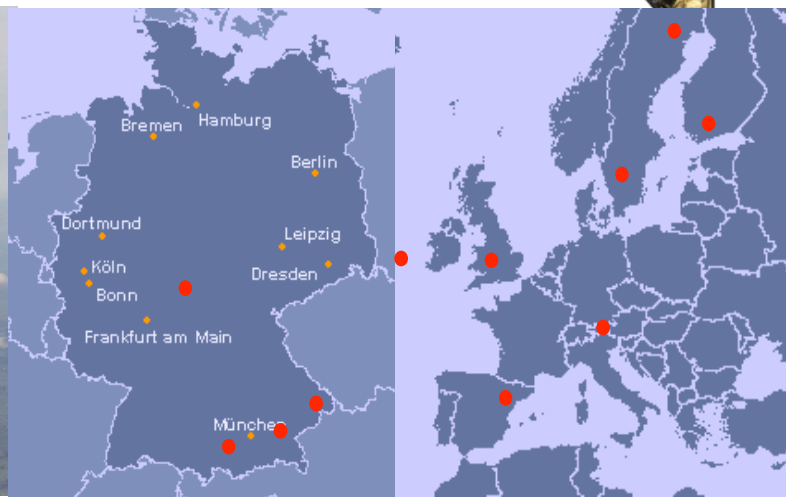
Year: 2000 Sensor: E-SAR (DLR)

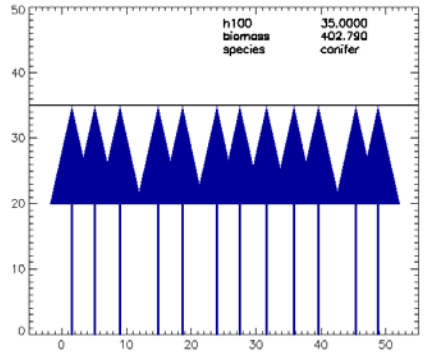
Test Site: Oberpfaffenhofen / Germany

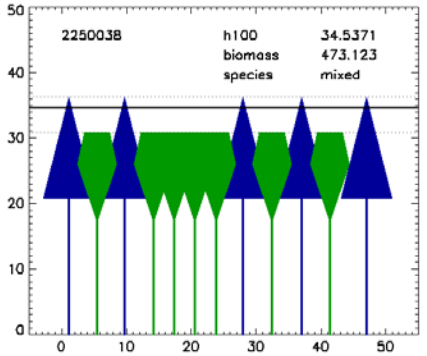


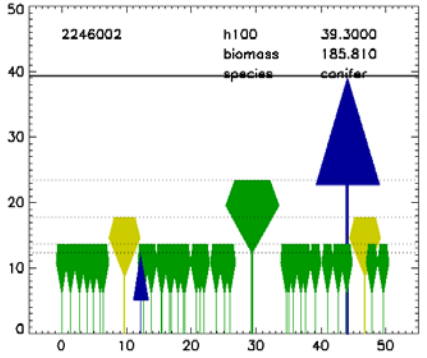


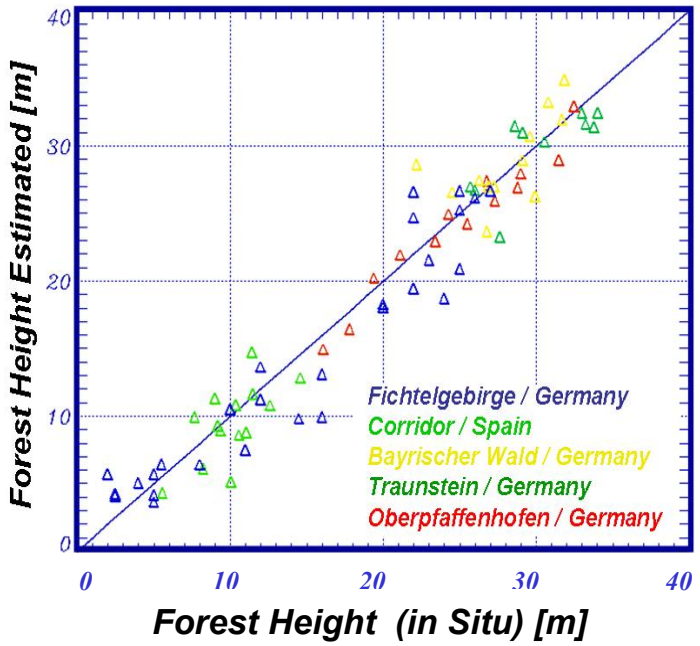
PolInSAR Forest Height Inversion (2000-2003)

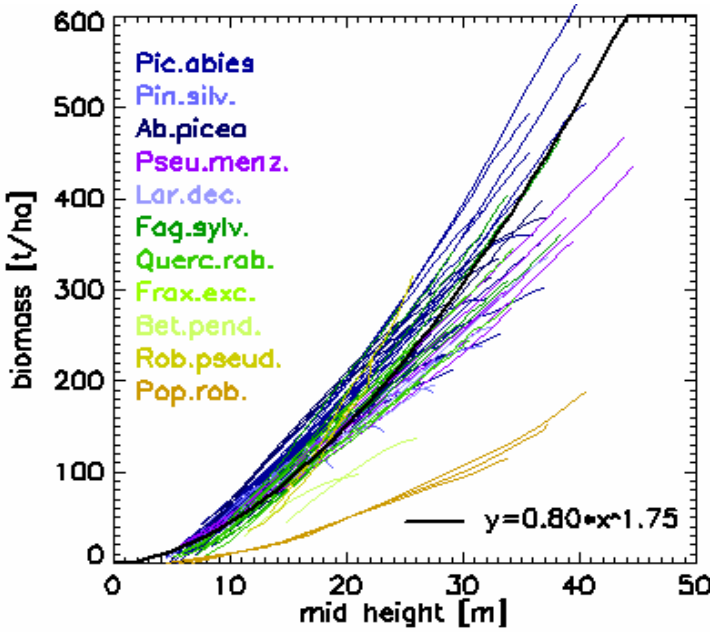








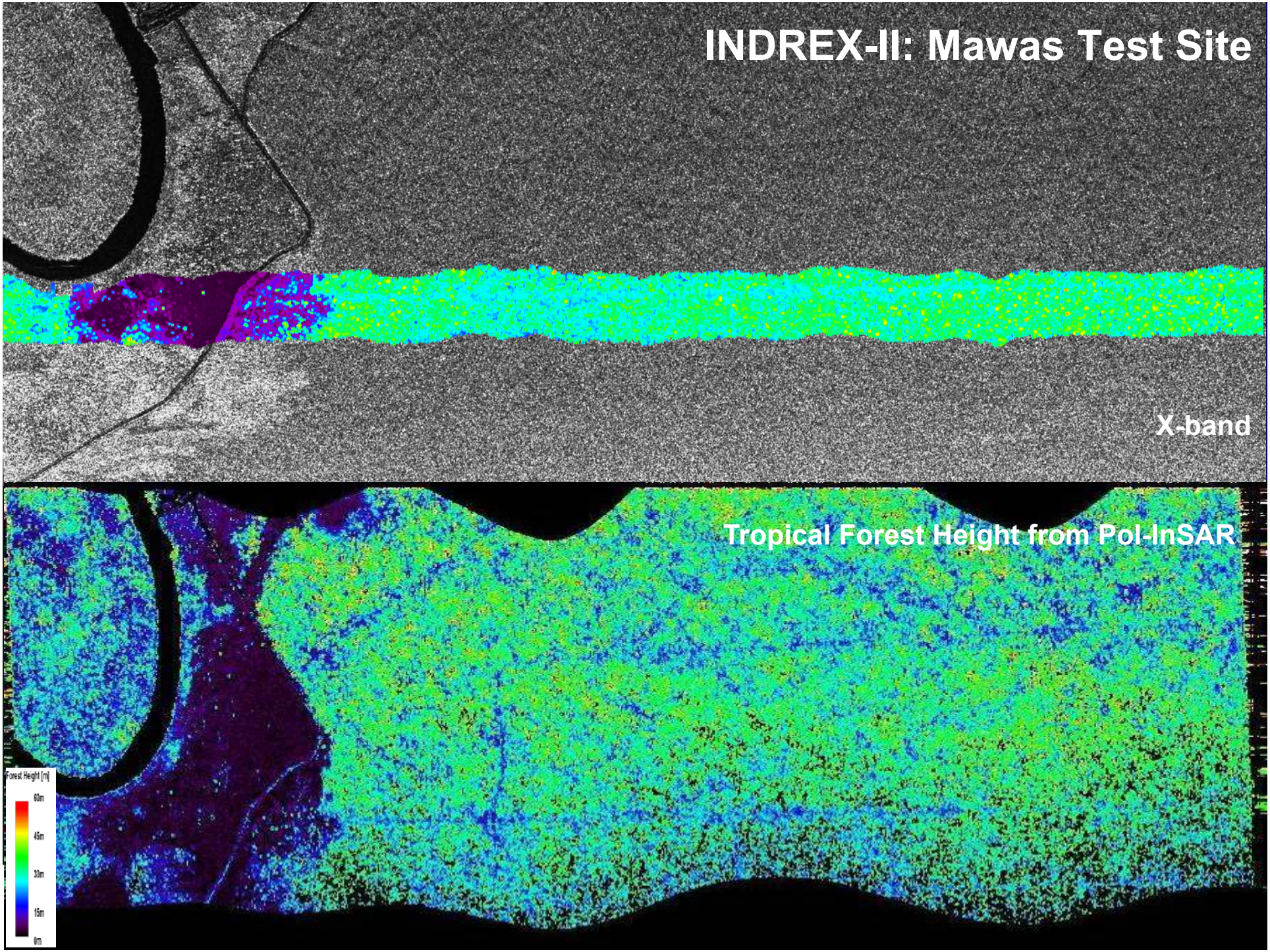




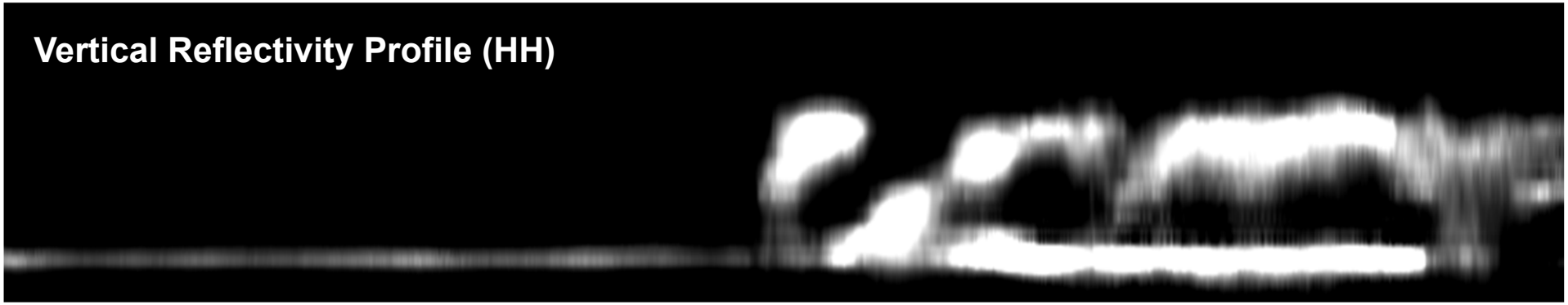
INDREX-II: 2004

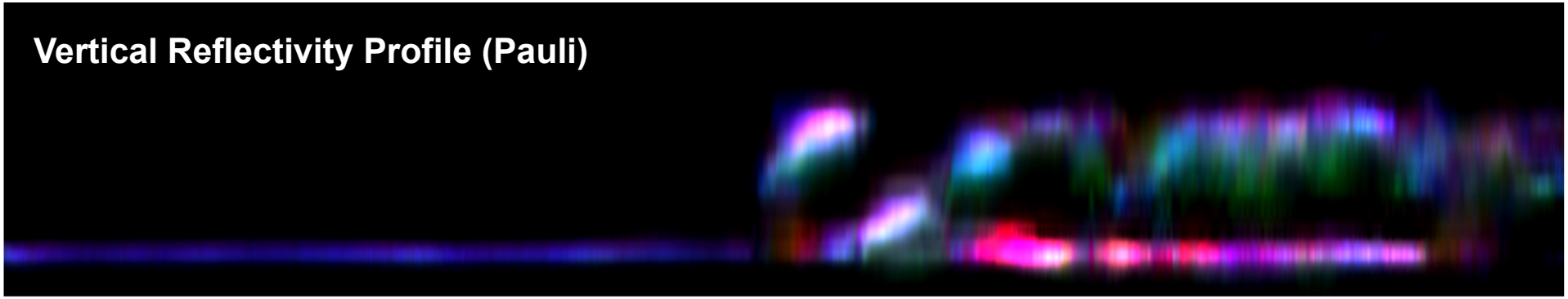
Validation of the Pol-InSAR techniques in tropical forest conditions:

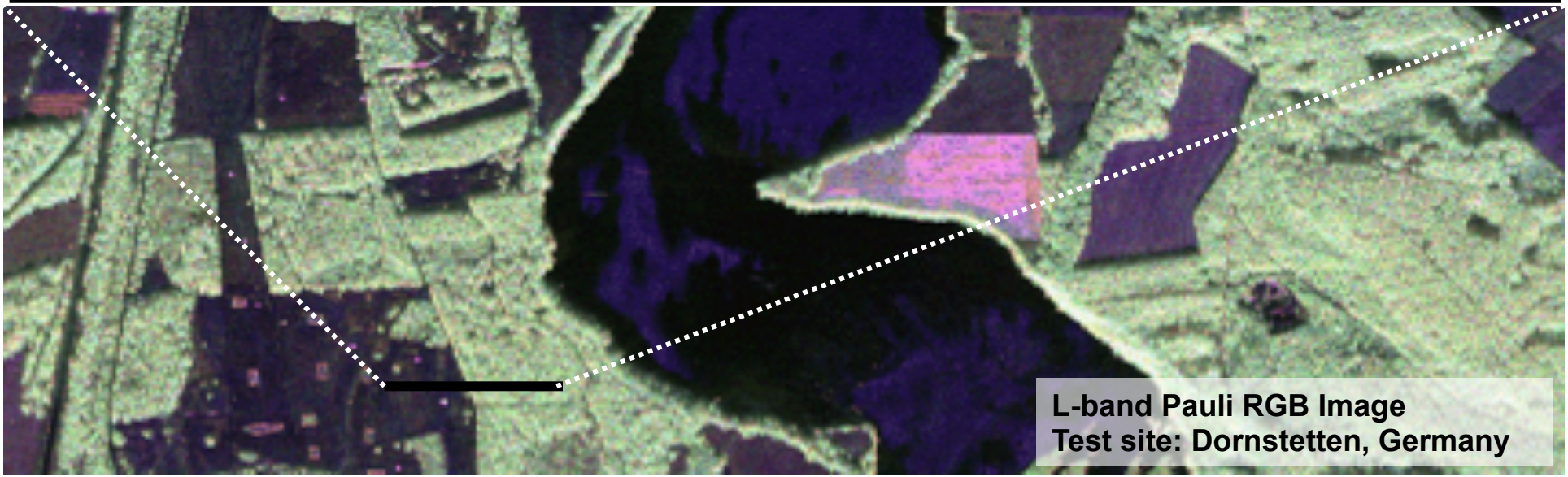
- Canopy Penetration @ L- and P-band;
- Sensitivity & Inversion validation;
- Height 2 Biomass alometry evaluation.


INDREX-II: Mawas Test Site
X-band
Tropical Forest Height from Pol-InSAR
Forest Height [m]
60m
45m
30m
15m
0m

Vertical Forest Profile Reconstruction

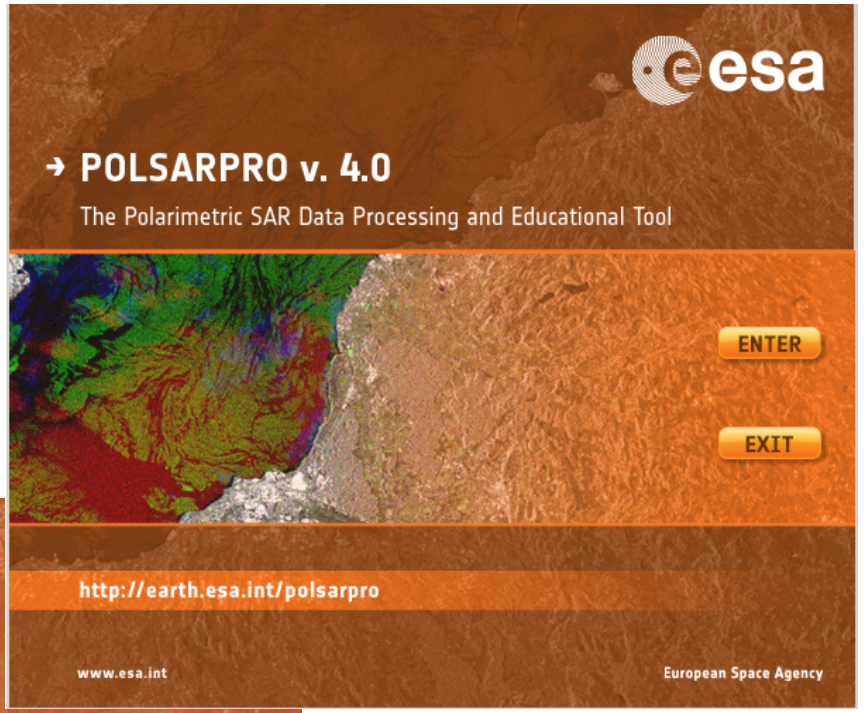






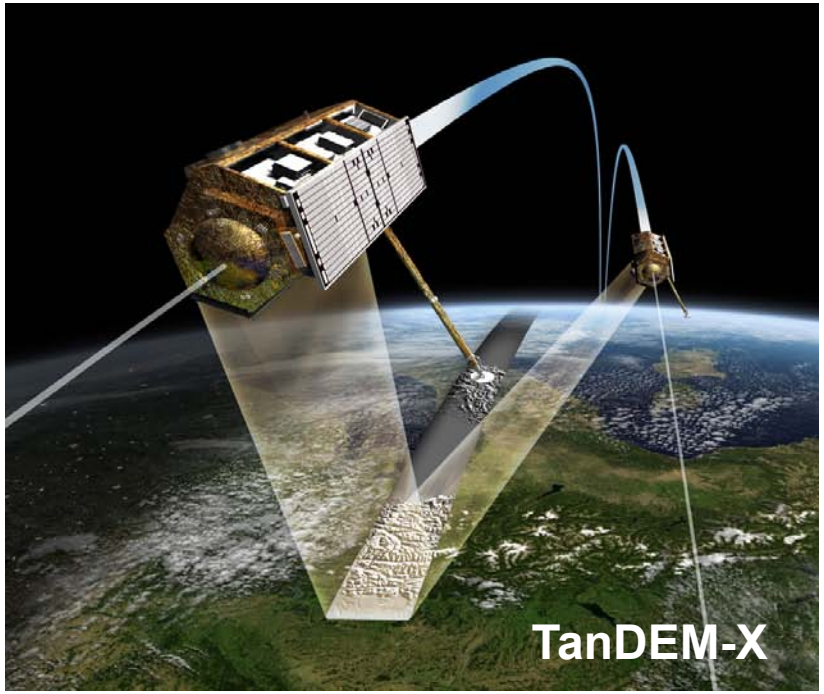
Advancement of Pol-InSAR in Europe

- First development in Germany and strong national support
- Support of the European Space Agency:
  - PolinSAR Workshops (2003, 2005, 2009, 2011)
  - PolSAR Pro 4.2 (free software)



Advancement of Pol-InSAR in Europe

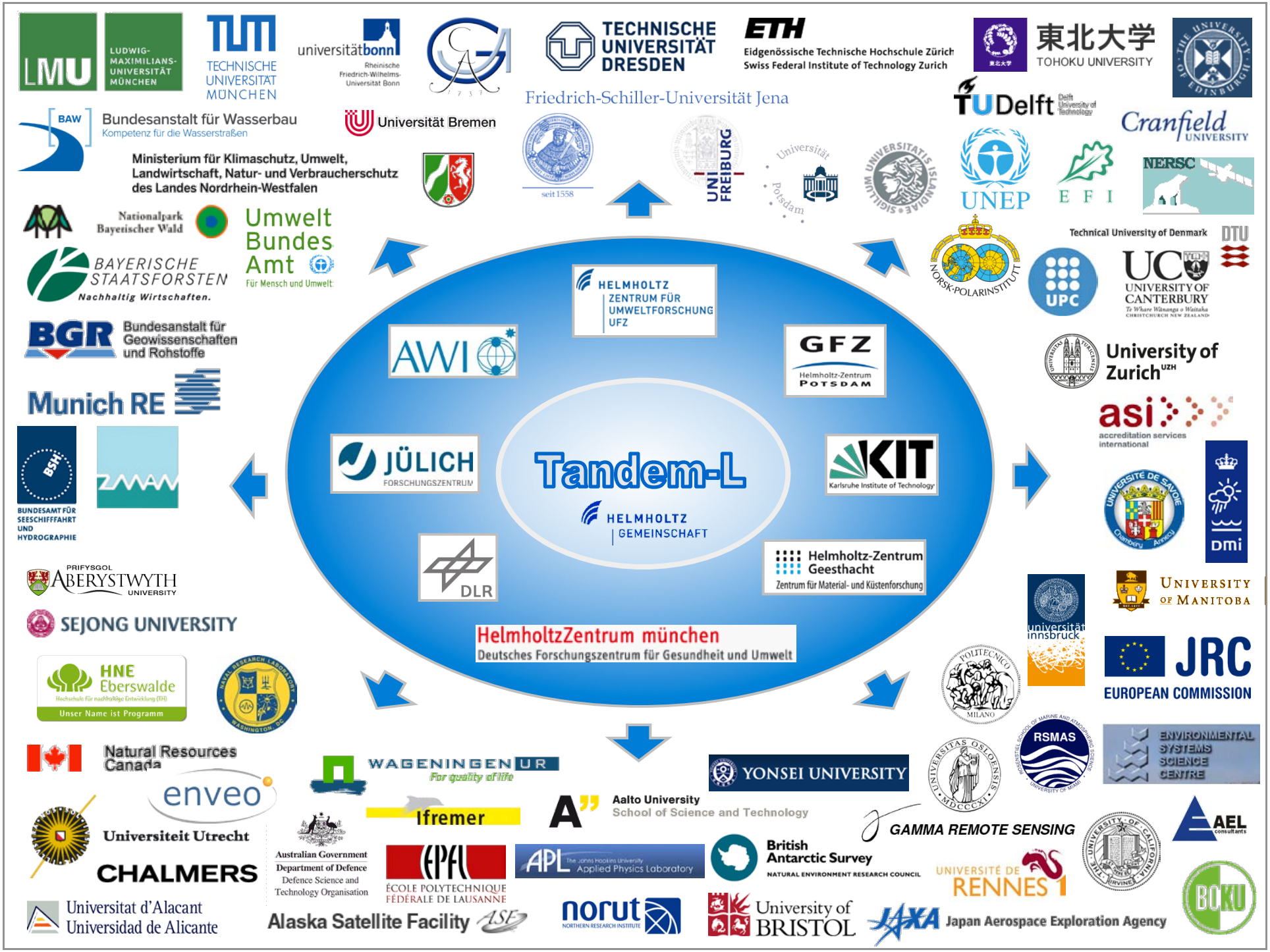
- First development in Germany and strong National support
- Support of the European Space Agency:
  - PolinSAR Workshops (2003, 2005, 2009, 2011)
  - PolSAR Pro 4.2 (free software)
- Outcome of the technology is a German national mission TanDEM-X (single pass SAR interferometer)
- A logic follow on is the German mission proposal of Tandem-L



Tandem-L

	Tandem-L Science Products	Resolution	Revisit
Biosphere	Forest height	20 - 50 m	16 days - seasonal
	Above ground biomass		
	Vertical forest structure		
Geo-/ Lithosphere	Plate tectonics	5 - 100 m	Weekly*
	Volcanoes		
	Landslides		
	Deformation		
Cryo- & Hydrosphere	Glacier flow	50 - 500 m	weekly*
	Soil moisture		weekly*
	Water level change		on demand
	Snow water equivalent		seasonal
	Ice structure change		seasonal
	Ocean currents		weekly*
Global	Digital terrain and surface model	20 - 50 m	yearly

DLR


Tandem-L
HELMHOLTZ GEMEINSCHAFT
HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ
AWI
GFZ Helmholtz-Zentrum POTSDAM
JÜLICH FORSCHUNGSZENTRUM
KIT Karlsruhe Institute of Technology
DLR
Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung
HelmholtzZentrum münchen
Deutsches Forschungszentrum für Gesundheit und Umwelt
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN
TECHNISCHE UNIVERSITÄT MÜNCHEN
universitätbonn Rheinische Friedrich-Wilhelms-Universität Bonn
TECHNISCHE UNIVERSITÄT DRESDEN
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
東北大学 TOHOKU UNIVERSITY
Friedrich-Schiller-Universität Jena
seit 1558
UNI FREIBURG
Universität Potsdam
TU Delft
Cranfield UNIVERSITY
BAW Bundesanstalt für Wasserbau Kompetenz für die Wasserstraßen
Universität Bremen
Ministerium für Klimaschutz, Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen
UNEP
E F I
NERSC
Nationalpark Bayerischer Wald
Umwelt Bundes Amt Für Mensch und Umwelt
BAYERISCHE STAATSFORSTEN Nachhaltig Wirtschaften.
NORSK POLARINSTITUTT
Technical University of Denmark
DTU
UPC
UC UNIVERSITY OF CANTERBURY
BGR Bundesanstalt für Geowissenschaften und Rohstoffe
University of Zurich UZH
Munich RE
asi accreditation services international
BSH BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE
ZAMG
Université de Savoie Chambéry Annecy
DMI
PRIFYSGOL ABERYSTWYTH UNIVERSITY
SEJONG UNIVERSITY
UNIVERSITY OF MANITOBA
universität innsbruck
JRC EUROPEAN COMMISSION
HNE Eberswalde Hochschule für nachhaltige Entwicklung (FH) Unser Name ist Programm
POLITECNICO MILANO
RSMAS
ENVIRONMENTAL SYSTEMS SCIENCE CENTRE
Natural Resources Canada
WAGENINGEN UR For quality of life
YONSEI UNIVERSITY
UNIVERSITAS OSLOENSIS MDCCCXI
enveo
Ifremer
Aalto University School of Science and Technology
GAMMA REMOTE SENSING
AEL consultants
Universiteit Utrecht
Australian Government Department of Defence Defence Science and Technology Organisation
British Antarctic Survey NATURAL ENVIRONMENT RESEARCH COUNCIL
UNIVERSITY OF CALIFORNIA IRVINE
CHALMERS
EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
APL The Johns Hopkins University Applied Physics Laboratory
UNIVERSITÉ DE RENNES 1
BOKU
Universitat d'Alacant Universidad de Alicante
Alaska Satellite Facility ASF
norut NORTHERN RESEARCH INSTITUTE
University of BRISTOL
JAXA Japan Aerospace Exploration Agency